DOSE ESTIMATION BASED ON CHROMOSOMAL ABERRATIONS IN HUMAN PERIPHERAL LYMPHOCYTES

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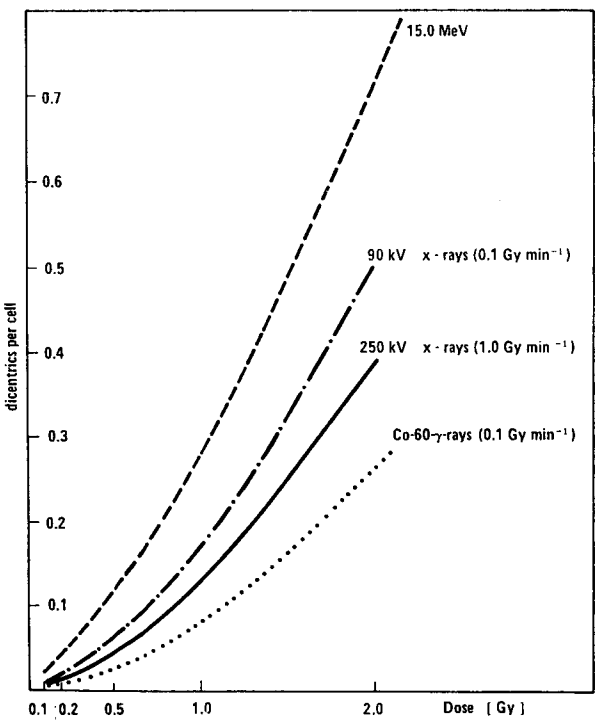
For dose estimation it is necessary to have a calibration curve which relates the radiation dose to the chromosomal aberration yield. In vitro curves were constructed for dicentric aberrations for several qualities of high and low LET radiation (Fig. 1).

Figure 1. Yields of dicentrics plotted against the dose for several radiation qualities (in vitro curves)



Data obtained on the aberration yield after exposure of cells by low LET radiation were found to be best fitted to the linear quadratic function $y = \alpha D + \beta D^2$, where y is the aberration yield, D the dose and α and β are the coefficients (Table 1). However, after irradiation with 15 MeV neutrons the curve shows a closer approximation to a linear function. The quotient α/β describes the dose, where the number of dicentrics produced by a

single and two ionizing track events is equal. Below these doses the majority of aberrations will be produced by single tracks. Thus, modifying the dose rate of low LET radiation, the dicentric rate will be mainly affected by higher doses where most of the dicentrics are induced by pairs of ionizing tracks represented by the term βD^2 in the equation.

Table 1. Coefficients α and β in the equation $y = \alpha D + \beta D^2$

Radiation type	$\alpha \pm SE \times 10^{-2}$	$\beta \pm SE \times 10^{-2}$	α / β
neutrons $\bar{E}$ = 15.0 MeV	24.9 ± 4.3	7.1 ± 2.0	3.5
250 kV X-rays (1.0 Gy min^{-1})	4.8 ± 0.3	7.4 ± 0.1	0.65
250 kV X-rays (0.4 Gy min^{-1})	7.7 ± 0.2	6.85 ± 1.07	1.12
250 kV X-rays (0.1 Gy min^{-1})	8.3 ± 0.1	5.03 ± 0.3	1.65
90 kV X-rays (0.1 Gy min^{-1})	7.3 ± 0.1	9.17 ± 0.4	0.8
Co-60-γ-rays (0.1 Gy min^{-1})	3.0 ± 0.1	5.3 ± 0.5	0.57

From this it is concluded that in practice the dose rate is hardly influenced by the dicentric yields found after an over-exposure of low LET radiation since in most cases of overexposure doses occur being lower than the described quotient α / β .

Each laboratory that performs "chromosome dosimetry" should have its own calibration curve because of the inter-laboratory differences.

From October 1982 to October 1983, 25 blood samples arrived per mail for "chromosome dosimetry". Table 2 shows that in the cases investigated there is a time lapse between exposure and sampling time. Therefore it is of great advantage to have an in-indicator for radiation exposure that remains detectable for some time after exposure.

Table 2. Time interval between radiation exposure and blood sampling

days	cases
7;10	2
11 - 30	1
> 30	8
chronic exposure	8
unknown	7

For dicentric chromosomes it was shown that within a few weeks after the exposure no remarkable alteration in the dicentric rate is observed (Preston, Brewen et al., Radiat. Res. 1974; 60, 516). On the other hand, it is also possible to estimate exposures after a longer interval between exposure and blood sampling. In two cases of an accidental whole body irradiation doses were estimated 30 weeks after the accident which were in good agreement with the film badge values (Stephan, Hadnagy et al. Health Physics 1983; 44, 409).

Table 3 demonstrates the importance of "biological dosimetry" based on chromosomal aberrations, particularly in those cases where physical dosimetry is not sufficient:

- known exposure, but no blackness on film badge
- possible exposure but film badge was not worn
- values of film badges are underestimating whole body dose because of the limited body region measured
- values from film badges are too high to be indicating the actually received dose

Table 3. Cases analysed

known exposure	6
film badge indicates a questionable exposure	5
suspected exposure of persons not wearing a dosemeter	5
chronic exposure	9
external: 4 internal: 5	

Table 4 shows the estimated doses based on chromosomal aberrations indicated as equivalent whole body doses.

Table 4. Numbers of estimates

Dose range (Gy)	cases
0 - 9	11
10 - 14	3
15 - 19	3
20 - 24	0
25 - 29	1

In most cases the equivalent whole body dose was estimated to be less than 0.1 Gy. This value appears to be the lower limit of sensitivity by using the chromosome aberration method. This limit is indicated by two factors: the spontaneous dicentric rate and the confidence limits of dose estimations.

The aberration rate differing from the spontaneous rate (7 dicentrics/13,741 lymphocytes) will give a dose estimate of about 0.05 Gy. The confidence limits are influenced by the number of scored cells (Table 5) and the frequency of dicentrics per unit dose.

Table 5. Influence of the number of cells examined on the 95% confidence limits (250 kV x-rays; 1 Gy min^{-1})

No. of cells	Dose estimate (Gy)	92% confidence limits (Gy)	
250	0.14	0.03	0.36
500	0.14	0.05	0.28
1000	0.14	0.06	0.23
1500	0.14	0.08	0.21
2000	0.14	0.09	0.20

In cases of high LET radiation the lower limit of the estimated doses is less in comparison to low LET radiation.

The results show that "chromosome dosimetry" may be of practical use for dose estimation and provides an important supplement to physical methods.

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